The Effect of Project-Based Stem Education Approach on Academic Achievement and Stem Career Interests in Science

Halil Tanır[1], Lütfullah Türkmen[2]

[1]*Uşak University, Faculty of Education, Department of Mathematics and Science Education, Department of Science Education, Uşak, Turkey*
[2]*Uşak University, Faculty of Education, Department of Mathematics and Science Education, Department of Science Education, Uşak, Turkey*

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ABSTRACT
The aim of this study is to determine the effect of the project-based STEM learning method prepared in accordance with the Science and Technology course curriculum on academic achievement and STEM Career Interest levels. Pre-test post-test control group experimental design was used in the study. In this context, the sample of the study consisted of 52 (n=26 experimental and n=27 control) volunteer 6th grade students studying in two different branches at Karatay Secondary School in Karatay district of Konya province in the second semester of 2021-2022 academic year. A placement test was administered in order to determine the branches in which the study would be conducted. According to the results of the exam, volunteer students studying in the closest level branches were included in the study. The students in the experimental group were taught according to the project-based STEM learning method prepared according to the outcomes of the Support and Motion System, Force and Motion, Sound Insulation, Thermal Insulation units for 64 lesson hours. The students in the control group were taught the above-mentioned units by the same instructor according to the existing program for 64 class hours. Both experimental and control group students were administered the skills-based academic achievement and STEM Career Interest Scale prepared by the Ministry of National Education as pre-test and post-test. The data obtained from the pre-test and post-test applications were evaluated in SPSS 26.0 package program. In the statistical analysis, it was found that there was a statistically significant difference between the students in the experimental and control groups in favor of the students in the experimental group ($p<0.05$). According to the findings obtained from the statistical analysis, it was concluded that the project-based STEM teaching method in science education increased the level of academic achievement and interest in STEM professions. Based on this result, it is predicted that students' academic achievement levels can increase with the more frequent use of project-based STEM learning method in science education by teachers

1. Introduction

STEM Education

STEM (Science, Technology, Engineering and Mathematics) is an approach that emphasizes associations between science, technology, engineering and mathematics disciplines and is based on teaching these fields as a whole. This approach is based on combining these disciplines in an interconnected learning paradigm in real life situations instead of teaching them separately (Hom, 2014). STEM refers to technology and engineering design-based learning that integrates science and mathematics concepts with the concepts of technology and engineering education (Sanders, 2012) and is based on combining these disciplines in a classroom based on the connections between real-world problems and issues (Stohlmann, Moore, & Roehrig, 2012). STEM can be taught in four different ways, emphasizing one or two topics as stand-alone subjects, integrating one STEM discipline into the other three, or blending the four disciplines (Dugger, 2010), and it does not always have to encompass all four disciplines (Stohlmann et al., 2012).

Project-Based STEM Education

Project-based STEM, as in all STEM teaching practices in which engineering discipline is integrated, is a model that aims to enable learners to create a product for solving real-life problems and involves the effective operation of the engineering design process (Capraro et al., 2013; Capraro & Slough 2013). This designed product can be a presentation, a poster, a drawing, a model or a project. In the design process, it gives students the opportunity to think like an engineer to solve the problems they face (Guzey & Jung, 2021). When the field studies on STEM integration are examined, it is seen that STEM applications bring together complex, unique or real-world problems with student-centered strategies by involving other disciplines (Fang & Fan, 2023; Larkin & Lowrie, 2023; Wan, 2022). In addition, the importance of finding solutions in collaboration and group work is emphasized (Moore, Johnston, & Glancy, 2020). In some studies, it has been stated that using STEM approach and project-based learning together is one of the effective strategies in STEM education (Bender, 2017; Selvi & Yıldırım, 2017). Because the aim of the project-based learning model is to identify a problem in the real world and to produce a solution to this problem, which is a process that involves continuous learning. In the project-based learning process, the main goal is for students to identify a real-world problem through research, to come up with a suitable solution to the problem and to develop 21st century skills in this process (Artama et al., 2023; Dean et al., 2023; Maros et al., 2023). On the other hand, with the project-based learning model, students evaluate both themselves and each other by collaborating with each other by providing the holistic effect of life problem, course and subject interaction in the process (Wolpert-Gawron, 2016). Therefore, Project-based STEM is an important learning model that aims to provide learners with the ability to produce solutions to real-life problems and to use the engineering design process effectively to achieve this goal. This model brings together different disciplines with student-centered strategies, focusing on complex and real-world problems that are at the core of STEM practices. The emphasis on collaboration and group work encourages students to interact with each other in the process of finding solutions. Based on this information, combining the STEM approach with project-based learning is thought to be an effective strategy to improve students' ability to produce solutions to real-world problems through a process involving continuous learning.

STEM Career Interest Relationship

Low socioeconomic status is seen as a barrier to the realization of the goals in the educational process and the progress of students towards a good career goal. Since individuals cannot change the family characteristics they are born with, studies on the academic and social success of individuals growing up in disadvantaged families gain importance (Gregorio & Lee, 2002). Bacanlı and Sürücü (2011) emphasize that there is a parallelism between the education level of parents and students' career awareness and development. The amount of time students spend studying and the presence of people who support them outside of school have a significant effect on their academic success (Engin & Demir, 2009). If at least one of their parents is involved in STEM-related professions, students are more likely to prefer to study STEM-related subjects than students who do not have parents in STEM-related professions (Harwell & Houston, 2012).

Relationship between STEM and Academic Success

STEM education, which generally focuses on science and mathematics, but also includes technology and engineering, is a collaborative working philosophy based on the application of knowledge, offering students comprehensive and meaningful real-life experiences (Bybee, 2010; Gomez & Albrecth, 2014). Research has shown that countries such as the United States, the United Kingdom, and Japan, which use STEM education in their education system, have grown economically and have increased their PISA and TIMSS exam results, which are conducted internationally and determine the science and mathematics levels of students (Sakarya, 2015). In the STEM action plan published by the Ministry of National Education, the Ministry of National Education (MEB). emphasized that STEM education should be prioritized in order to provide students with the knowledge and skills targeted to be gained in curricula and to achieve successful results in exams such as TIMSS and PISA (Ministry of National Education (MEB), 2016).

Purpose

The aim of this study is to examine the effects of the project-based STEM learning method prepared according to the achievements of the 6th grade Support and Motion System, Force and Motion, Sound Insulation, Thermal Insulation units on students' academic achievement and STEM Career Interests compared to the teaching method prepared according to the current curriculum. Does the project-based STEM learning method prepared according to the achievements of the units determined within the framework of this purpose make a statistically significant change on students' academic achievement and STEM Career Interests compared to the teaching method prepared according to the current National Education Curriculum? It was tried to find an answer to the question.

2. Method

In the study, a pre-test post-test control group experimental design was used to determine whether teaching according to the Project-Based STEM learning method and teaching according to the current program have different effects on student achievement and STEM Career Interests.

The population of the study consists of all 6th grade students in Konya Province. The sample of the study consists of a total of 53 students studying in a middle school in Karatay district of Konya Province. While selecting these two classes of students, a skills-based academic achievement test and the STEM Career Interest Scale introduced to the literature by Koyunlu Unlu, Z., Dokme, İ., & Unlu, V. (2016) were applied to the 6th graders in the school for two volunteer classes. Activities were carried out for a total of 64 lesson hours in the experimental and control groups within the 4 units determined. In this context, as a result of the activities lasting 4 months, the skill-based academic achievement test prepared by the Ministry of National Education and the STEM Career Interest Scale were applied as a post-test.

3. Findings and Discussion

The findings obtained for the first sub-problem of the research, "When the average scores of the experimental and control groups obtained from the academic achievement test and STEM Career Interest Scale before the application are controlled, is there a significant difference between the average scores obtained from the academic achievement test and STEM Career Interest Scale after the application?" are given under this title. In this context, the academic achievement test and STEM Career Interest Scale were applied to the groups as pre-test and post-test. Descriptive data regarding the mean scores of the groups obtained from the academic achievement test and STEM Career Interest Scale pre-test and post-test before and after the application are shown in Table 1 and Table 2.

Table 1. Descriptive Data Regarding the Pre-Test and Post-Test Score Averages Obtained from the Academic Achievement Test

Test	Groups	N	SS	$\bar{x}$
Pre-test	**Experimental Group**	26	1,5791	5,576
	Control Group	27	1,4272	6,037
	Total	53	1,5031	5,806
Post-test	**Experimental Group**	26	2,7433	12,615
	Control Group	27	2,1897	8,444
	Total	53	2,4665	9,400

Table 2 Descriptive Data Regarding the Pre-Test and Post-Test Score Averages Obtained from the STEM Career Interest Scale

Test	Groups	N	SS	$\bar{x}$
Pre-test	**Experimental Group**	26	10,395	147,076
	Control Group	27	9,814	143,111
	Total	53	10,104	145,058

Post-test	**Experimental Group**	26	10,084	158,461
	Control Group	27	10,108	144,888
	Total	53	10,096	151,674

When Table 1 is examined, it is seen that the mean pretest score of the experimental group is x̄:5,576 and the mean pretest score of the control group is x̄:6,037. It can be said that there is no statistical difference between the experimental and control groups before the application.

When Table 2 is examined, it is seen that the mean pretest score of the experimental group is x̄:147,076 and the mean pretest score of the control group is x̄:143,111.

ANCOVA test was performed to examine the differentiation between the posttest scores obtained from the Academic Achievement and STEM Career Interest Scale in the experimental group and the control group. For this purpose, the adjusted averages between the post-test scores after the pre-test scores of the Academic Achievement and STEM Career Interest Scale, which were taken as covariates, are given in Table 3 and Table 4.

Table 3 Adjusted Posttest Mean Scores of the Experimental and Control Groups According to the Mean Scores of the Pre-Test Academic Achievement Test

		Pre-test		**Post-test**		**Corrected Mean**
Grups	**N**	$\bar{X}$	**Ss**	$\bar{X}$	**Ss**	$\bar{X}$
Experimental Group	26	5,57	1,57	12,61	2,74	12,71
Control Group	27	6,03	1,42	8,44	2,18	8,14

Table 4 Adjusted Posttest Means of the Experimental and Control Groups According to the Pre-Test STEM Career Interest Scale Scale Scores

		Pre-test		**Post-test**		**Corrected Mean**
Grups	**N**	$\bar{X}$	**Ss**	$\bar{X}$	**Ss**	$\bar{X}$
Experimental Group	26	147,07	10,39	158,46	10,08	157,60
Control Group	27	141,44	9,81	144,88	10,10	149,40

When the adjusted posttest mean scores of the experimental and control groups were analyzed in Table 3, it was seen that the posttest mean of the experimental group was higher than the control group. In the experimental group in which project-based STEM education was applied, while the average before the application was $\bar{X}$:5,57, this value was $\bar{X}$:12,71 as a result of the application.

When the adjusted posttest mean scores of the experimental and control groups were analyzed in Table 4, it was seen that the posttest mean of the experimental group was higher than the control group. In the experimental group where project-based STEM education was applied, while the mean was $\bar{X}$:147.07 before the application, this value was $\bar{X}$:157.60 after the application.

The ANCOVA test results regarding whether the difference between the adjusted posttest scores obtained from the academic achievement test and STEM Career Interest Scale of the experimental and control groups is statistically significant are given in Table 5 and Table 6.

Table 5 ANCOVA Results for Posttest Scores Adjusted for Academic Achievement Pre-test

Source of Variance	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**	η_p^2

Pre-test	575,557	1	575,557	91,220	,000	,470
Groups	89,661	1	89,661	14,210	,000	,121
Error	649,886	103	6,310			
Total	8505,000	106				

*p<.05

Table 6 ANCOVA Results for Posttest Scores Adjusted for STEM Career Interest Scale Pre-test

Source of Variance	Sum of Squares	df	Mean Square	F	p	η_p^2
Pre-test	534,377	1	534,377	2,514	,116	,024
Groups	847,864	1	847,864	3,990	,048	,037
Error	21889,910	103	212,523			
Total	2340954,000	106				
*p<.05						

When Table 5 is examined, it is seen that there is a significant difference between the groups in terms of post-test mean scores adjusted according to the academic achievement pre-test (F(1-106) = 14,210; p = 0,000 < .05).It can be said that this difference is in favor of the experimental group.

When Table 6 is examined, it is seen that there is a significant difference between the posttest mean scores corrected according to the academic achievement pre-test between the groups (F(1-106) = 3,990; p = 0,048 < ,05).This difference can be said to be in favor of the experimental group.

The second sub-problem of the research, Project-Based STEM education applied in the experimental group, does it create a significant difference in students' academic achievement and STEM Career Interest levels? Whether there is a statistically significant difference between the scores of the experimental group students at the beginning and end of the study was analyzed using t-test and the results are given in Table 7.

Table 7 T-Test Results of Experimental Group Students' Academic Achievement Test Pre-Test Achievement Scores and Post-Test Achievement Scores

Experimental Group	N	X	SS	Sd	t	P
Pre-test	26	5,576	1,579	0,309	18,007	,000
Post-test	26	12,615	2,743			

*p<.05

Table 8 T-Test Results of Experimental Group Students' STEM Career Interest Scale Pre-Test Achievement Scores and Post-Test Achievement Scores

Experimental Group	N	X	SS	Sd	t	P
Pre-test	**26**	**147,070**	**13,624**	**2,672**	**2,048**	**0,046**
Post-test	**26**	**158,460**	**8,328**			

***p<.05**

When Table 7 and Table 8 are examined, it is seen that there is a statistically significant difference between the pre-test and post-test scores of the experimental group in favor of the post-test (p<.05). According to these findings, it can be said that the project-based STEM education method has a positive effect on student achievement and STEM career interests. The fourth sub-problem of the research was expressed as "Does the teaching according to the current program create a significant difference in the academic achievement levels and STEM career interest levels of the students"? Whether there is a statistically significant difference between the scores of the control group students at the beginning and end of the study was analyzed using t-test and the results are given in Table 9 and Table 10.

Table 9 T-Test Results of Control Group Students' Academic Achievement Test Pre-Test Achievement Scores and Post-Test Achievement Scores

Experimental Group	**N**	**X**	**SS**	**Sd**	**t**	**P**
Pre-test	27	6,037	1,427	0,274	21,979	,000
Post-test	27	8,444	2,189			
*p<.05						

Table 10 T-Test Results of Control Group Students' STEM Career Interest Scale Pre-Test Achievement Scores and Post-Test Achievement Scores

Control Group	**N**	**X**	**SS**	**Sd**	**t**	**P**
Pre-test	27	141,444	9,528	1,833	2,048	0,046
Post-test	27	144,880	19,480			
*p<.05						

When Table 9 and Table 10 are examined, it is seen that there is a statistically significant difference between the pre-test and post-test scores of the control group's Academic Achievement Test and STEM Career Interest Scale in favor of the post-test (p<.05). (According to these findings, it can be stated that the current program has a positive effect on students' academic achievement and STEM career interest.

As a result of the analysis of the quantitative data of the research, a statistically significant difference was observed in favor of the experimental group in terms of the academic achievement levels and STEM Career Interests of the experimental group taught with the Project Based STEM Learning method and the control group taught with the current program.

Ceylan (2014) found that the application of the instructional design prepared on the basis of STEM education on the subject of acids and bases in the 8th grade middle school science course, students' academic achievement, academic achievement, creativity and problem solving skills of the students in the experimental group were more successful than the students in the control group.

Irkçatal (2016) conducted a study to determine the effect of after-school STEM activities involving engineering design processes on seventh grade students' achievement in the subject of simple machines, their perceptions towards engineering and technology concepts, their attitudes towards STEM fields and their interests. As a result of the study, it was concluded that after-school activities positively affected students' academic achievement in the subject of simple machines.

Alıcı (2018) conducted a study to examine the effects of problem-based STEM education on students' attitudes, career perceptions and vocational interests and to determine students' opinions about the applications. As a result of the application, it was found that students' attitudes towards STEM disciplines, STEM career perceptions and vocational interests in STEM fields increased statistically significantly.

In the study conducted by Çevik (2018) to determine the effect of project-based STEM education on the academic achievement and vocational interest of vocational high school students, it was found that STEM-PJT education significantly increased academic achievement and positively affected vocational interest in students.

Yıldırım and Altun (2015) conducted a study to determine the effect of STEM education and engineering applications on academic achievement in science and technology course. As a result of the application, a significant difference was found in favor of the experimental group in which STEM education and engineering education were applied in academic achievement scores. In line with these results, it was concluded that STEM education has a positive effect on students' academic achievement in science course.

With the Project-Based STEM education method, it is thought that there is a need for teaching environments where students will actively take part in the teaching process, are given the opportunity to propose various solutions to the problems they encounter, can use their imagination skills, make original and innovative designs and exhibit their creativity. In addition, it is also very important to combine the activities carried out in the teaching process with different disciplines and to apply them by associating them with daily life.

In general, STEM applications differ from the traditional education approach by their nature and are more fun for students because they are design-based. In order to ensure students' retention in STEM, teachers should use interesting teaching tools, communicate effectively, be enthusiastic in STEM teaching and relate the subject to daily life. In this context, it can be thought that interest in STEM professions will increase.

These results can influence the curriculum of future STEM activities so that teachers can be encouraged to develop rich, learning environments and hands-on activities that provide experiences to emphasize careers in STEM fields. These ideas can also be extended to the more formal learning environments of schools. If science, technology, engineering and mathematics teachers can see the impact of informal learning, they can be encouraged to incorporate authentic informal learning methods into their classrooms. Incorporating experiences such as field trips to STEM-related fields or inviting guest speakers from these fields to speak in the classroom can increase students' interest in STEM fields. Overall, the development and exploration of STEM practices can potentially improve STEM education as a whole and encourage students to pursue careers in ever-expanding scientific fields.

Suggestions for Project-Based STEM Education

It should be designed as areas where students are encouraged to learn by exploring; where they can make observations, experiments, etc. related to STEM projects, where students' project-based learning processes are supported, and where teachers guide and encourage their students in their projects and studies. It should be designed as a learning environment where students can collaborate with their fellow students and teachers in the implementation and realization of STEM projects and develop project-based learning skills by helping each other, and learn teamwork. It should be designed as learning spaces where students can produce the STEM projects they realize at school at their own pace by themselves or by doing group work.

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